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APPLICATION OF AGE-LENGTH-KEYS TO ESTIMATE CATCH-AT-AGE FOR THE NORTH ATLANTIC ALBACORE (*THUNNUS ALALUNGA*) STOCK

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SUMMARY

*This document presents the results of applying two different methods to estimate catch-at-age for North Atlantic albacore (*Thunnus alalunga*). The Spanish albacore surface fishery size frequency data from 2003 to 2005 have been analyzed by means of MULTIFAN and age-length-keys (ALKs) have been derived from readings of sections obtained from sampled dorsal spiny rays of catch landed.*

RÉSUMÉ

*Ce document présente les résultats de l'application de deux méthodes différentes visant à estimer la prise par âge pour le germon de l'Atlantique Nord (*Thunnus alalunga*). Les données de fréquences de tailles de la pêcherie de surface espagnole ciblant le germon de 2003 à 2005 ont été analysées à l'aide de MULTIFAN et des clefs âge-taille ont été calculées (ALKs) d'après la lecture des sections obtenues des rayons épineux de la dorsale échantillonnées de la prise débarquée.*

RESUMEN

Este documento presenta los resultados de aplicar dos métodos distintos para estimar la captura por edad del atún blanco del Atlántico norte. La distribución por talla de las capturas comerciales de las flotas españolas de superficie fue analizada con MULTIFAN. Las claves talla edad fueron obtenidas por medio de la lectura de secciones de radios espinosos muestreados a partir de las capturas comerciales.

KEYWORDS

Thunnus alalunga, albacore, surface fishery, age-length-keys, age composition, North Atlantic

1. Introduction

The length composition of albacore caught in the North Atlantic is available for all the fisheries: surface and long-line (Anon., 2004). For the assessment of the North stock it is required to estimate the catch at age distribution of the international albacore to be analysed with ADAPT-VPA model (Porch *et al.*, 2001).

The catch-at age matrix is derived from the analyses of the size composition of international catches by applying a maximum likelihood method MULTIFAN (Fournier *et al*, 1990) and use this matrix for assessing the state of the North Atlantic albacore stock (Anon., 2000). This likelihood method has become a standard procedure to estimate the age composition of the catch-at-size for North Atlantic albacore stocks (Santiago and Arrizabalaga, 2001; Arrizabalaga and Santiago, 2003). For the last two decades beginning in 1986, the largest proportion of exploited albacore in this stock is represented by the immature albacore age-groups 1 to 5 (Anon. 2004).

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Studies to estimate age composition of north Atlantic albacore based on skeleton structures, such as dorsal spiny rays, allow for more detailed information on albacore growth rates on annual bases. Among vertebrae, otolith and the first dorsal spine, this last one skeleton piece remains as the most validated ageing structure for albacore and specially when ageing adult fish (Fernández, 1992; Bard, 1981).

The aim of this paper is to present an application of the age length keys to estimate the catch-at age composition of albacore surface fishery landings and compare the results with the MULTIFAN length frequency method used to obtain the catch-at age.

2. Materials and methods

2.1 Data

Albacore samples were obtained by means of the sampling Spanish Institute of Oceanography (*Instituto Español de Oceanografía, IEO*) from the network on main fishing ports of the landings from trips of troll and bait boat fleets, starting in early June and finishing in October. During the landing operation, observers sampled decked albacore to collect the first dorsal spiny ray, measuring fork length to the nearest centimetre and recording date and fishing location for each specimen. A total of 330, 376 and 346 spines were selected to estimate the age composition of the Spanish surface albacore catches in 2003, 2004 and 2005, respectively.

2.2 Ageing procedure and Age-length keys

Albacore spiny rays were returned to the IEO laboratory and processed following the method described by Bard and Compeán (1980). The transverse cross-sections (~ 0.4 µm) mounted on slides and embedded in epoxy resin were read with transmitted light on a profile projector (NIKON 6C) at x10 or x20 magnification. The criteria used to interpret the pattern of observed translucent bands (*annuli*) formed on the spine sections of albacore, was based on the hypothesis of Bard and Compeán (1980), which assumes that the formation of two translucent bands (*annuli*) per year throughout the life span of North Atlantic albacore corresponds to its migratory behaviour between feeding and spawning grounds (Bard, 1981). Occasionally, to overcome the problem of resorption of the central zone of the spine as the fish grows, back calculation was applied based on the diameter of the first visible *annuli* measured (Ortiz de Zárate *et al.,* 2005). An age was assigned to the first visible *annuli* and by counting successive *annuli*, the sample was aged. This age estimation procedure has been tested to estimate the precision and agreement of the aging method (Eltink, 2000) amongst three different readers for North Atlantic albacore (Ortiz de Zárate *et al*., 2005).

Intercalibration among three readers in the 2003 collection reached 78.8% mean agreement and overall coefficient of variation (CV) of 8.7%. Same procedure was performed for the samples collected in 2004 and 2005 fishing seasons and level of mean agreement was 86% and 80% for 2004 and 2005 readings respectively and the respective overall coefficient of variation (CV) estimated were 9% and 7.6% (Eltink, 2000). Total annual number of samples prepared for ageing was: 330, 376 and 346 first dorsal fin ray sections for 2003, 2004 and 2005 years. The albacore length distribution covered was from 41 cm to 111 cm fork length (FL), 39 cm to 112 cm FL and 42 cm to 114 cm FL for consecutive years studied.

According to seasonal activity of fleets each annual age-length key was split into summer and autumn months and applied to length distributions of each fleet based on this time strata, then added to obtain the annual age composition and finally both fleets aggregated by year covered.

2.3 Length-frequency analysis

The catch at size distribution from 2003, 2004 (Ortiz de Zárate *et al.*, 2005) and 2005 data set was obtain using the statistical procedures to estimate Task II (length frequency) statistics of ICCAT, as is reported on annual bases for the Spanish surface fishery (Anon. 2004). Monthly length frequency distribution obtain in this way for the commercial catch landed by the Spanish troll and bait boat fleets operating from June to October in the North eastern Atlantic ocean were analysed by means of MULTIFAN 32 program from Otter Research, Ltd., 1992 (Fournier *et al*, 1990). The month interval is the shortest interval that could be set to allow for the progression of different modes as they appear during the seasonal surface fishery of albacore in the north east Atlantic. This model uses a likelihood-based approach to obtain the estimates of age composition.

Different values of the von Bertalanffy K parameter (0.15, 0.20, 0.25, 0.30) and number of age classes (5, 6, 7 and 8) were fixed in the initial search. Three systematic searches were tested: Model 1 had constant standard deviation at age, Model 2 had age-dependent standard deviation in length at age and Model 3 had both age-dependent standard deviation in length at age and seasonality in growth. In the absence of information on the age of the first class, MULTIFAN assumes that the von Bertalanffy curve passes through the origin (to=0). Estimates of age-at-length are based on this assumption.

A χ^2 test is used to compare the log-likelihood function values of the different models fit, in order to determine objectively the best solution.

3. Results

The "best" fit was obtained with model 3 which included age dependent standard deviation and seasonal growth. Systematic search results for this model are shown in **Table 1**. The best candidate for each age class is underlined and the one selected based on the χ^2 test value was the seven age classes. The estimated von Bertalanffy growth parameters for this search were $L\infty$ =116.6 cm and K= 0.188 (1/year).

The length frequency data set used and the expected one matched reasonable well **(Figure 1).** The estimated age for the youngest detected age group is quite high (1.99 years) which in part is due to the assumption of to=0.

The mean fork length (FL) at age and standard deviation obtained by the two methods: length frequency analysis and fin ray section readings are summarised in **Table 2**. Only results of 1 to 7 age groups are included according to the age composition obtain by MULTIFAN method. Nevertheless the number of samples collected for older age fish (> 7 years old) represents a testimonial presence in the catch and this age range covers an average of 96% of single annual collection for the three consecutive years.

Mean lengths at age obtained from readings of spines sections are quite similar among years with the exception of mean length at 5 years old in 2003, which is lower compare to the other two time series **(Table 2).**

The number at age obtained by the two methods applied to the catch-at size distribution of albacore surface fishery is presented in **Figure 2**. Visual examination of histogram reveals no major differences but the fishing season of 2005, when clearly age 3 and 4 show different estimates.

4. Discussion

This likelihood method has become a standard procedure to estimate the age composition of the catch-at-size for North Atlantic albacore stock (Santiago and Arrizabalaga, 2001; Arrizabalaga and Santiago, 2003).

In **Figure 3** it is observed the variation among the mean length at age obtained in these study and two North Atlantic albacore von Bertalanffy growth models. Mean length at age derived from ALK is very similar to that obtained by Bard using the first dorsal fin ray section (1981). Recently a more comprehensive study using a combination of first dorsal fin ray and tagging data obtained similar growth parameter estimates (Santiago and Arrizabalaga, 2005) which supports the utility of this method when calculating catch-at age data for immature fish (1-5 years old fish). However when contrasting the results from MULTIFAN larger difference is observed on average growth by age.

The use of skeleton structures (i.e first dorsal fin ray) that record the chronology of lifetime changes that can be interpreted to assign age, represent an advantage when the fish growth is affected by physical habitat variables and forage availability and quality. This appears to be a plausible explanation for the observed difference between the results of this method and length frequency analyses age structure obtain in 2005 **(Figure 2)**. Once agreement and precision between readers has been reached and periodicity of growth increments have been validated presents the advantage of give a biological interpretation of the annual growth cycle.

The catch at age matrix currently used in albacore assessments is derived from catch length composition using MULTIFAN. This is probably the most objective method from statistical point of view. Nevertheless, the age-length keys obtained from readings of dorsal spine sections show that is an alternative method that could be used to age juvenile albacore (1-5 ages) caught by surface fleets.

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Table 1. Systematic search results for Model 3. Two times the log-likelihood values are shown with the number of estimated parameters shown below in parentheses. The maximum values for each number of age classes are underlined.

Number of Age classes	Initial estimates of K			
	0.150	0.200	0.250	0.300
5	8800.00 (67)	8789.00 (67)	8135.00 (67)	8772.00 (67)
6	**8921.00** (82)	8914.00 (82)	8877.00 (82)	8877.00 (82)
7	8948.00 (97)	8948.00 (97)	**8954.00** (97)	8922.00 (97)
8	8989.00 (112)	8990.00 (112)	8992.00 (112)	**8973.00** (112)

Table 2. Mean fork length (FL) at age and standard deviation obtained by MULTIFAN and Age length keys methods.

AGE	ALK 2003 (cm)			ALK 2004 (cm)			ALK 2005 (cm)			MULTIFAN 2003-2005 (cm)	
	Media	SD	n	Media	SD	n	Media	SD	n	Media	SD
1	51	5,4	80	47	5,5	84	52	4,9	54	42	2,2
2	63	4,0	60	62	3,6	70	63	4,1	57	55	2,6
3	75	4,9	52	76	5,1	84	76	5,4	66	66	3,0
4	85	6,0	62	85	4,0	81	86	5,4	56	74	3,4
5	94	5,5	36	89	5,3	24	95	5,2	44	82	3,7
6	99	3,5	14	99	4,0	11	101	4,9	41	88	4,1
7	102	3,1	14	103	5,6	10	102	3,5	13	93	4,3
Total			318			376			346		

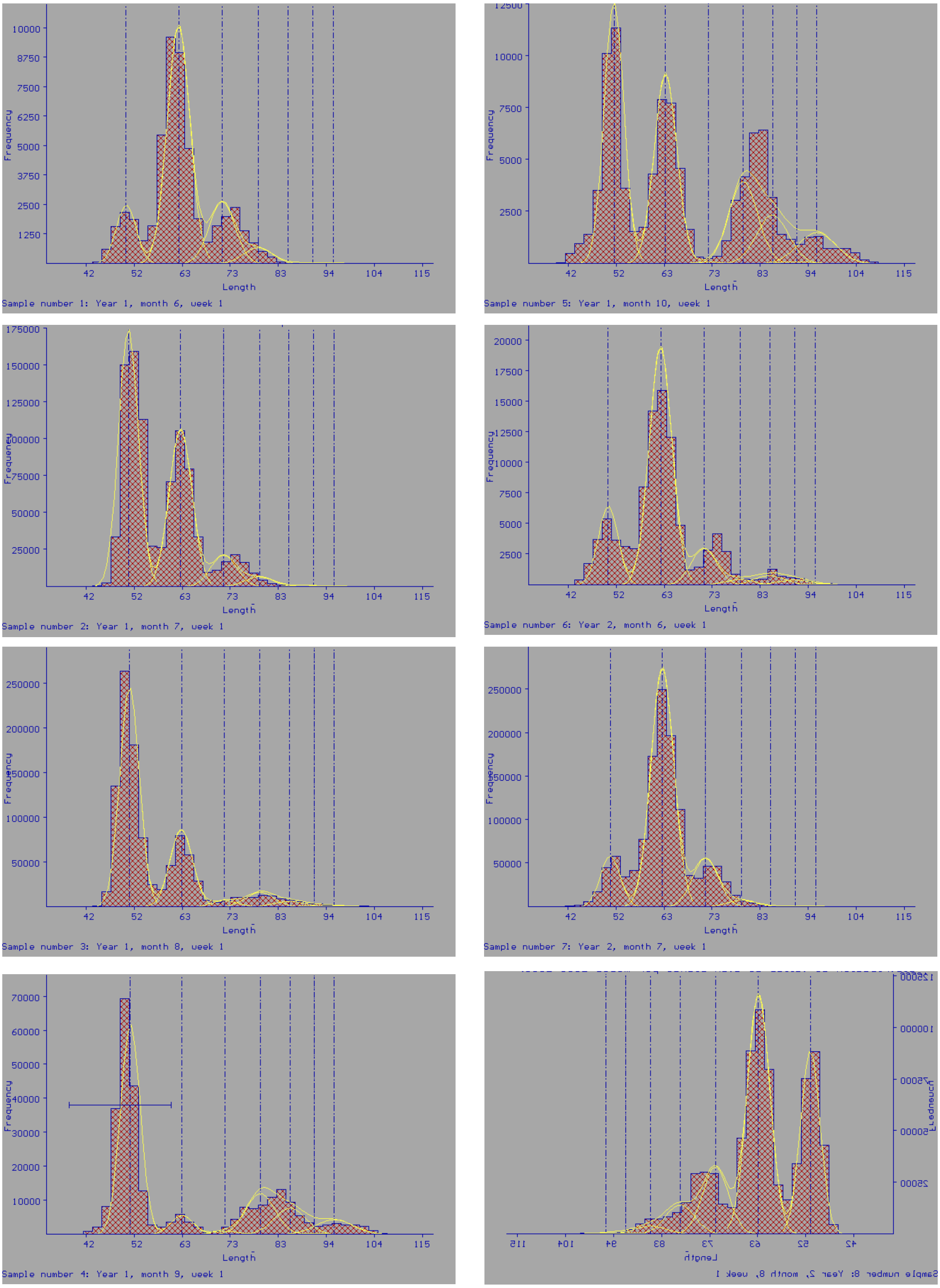

Figure 1. Monthly length frequency distributions for the Spanish albacore surface fishery catch in 2003-2005. Bars indicate observed data and lines are MULTIFAN estimates from Model 3 fit. The dashed vertical lines represent the estimated mean length-at-age.

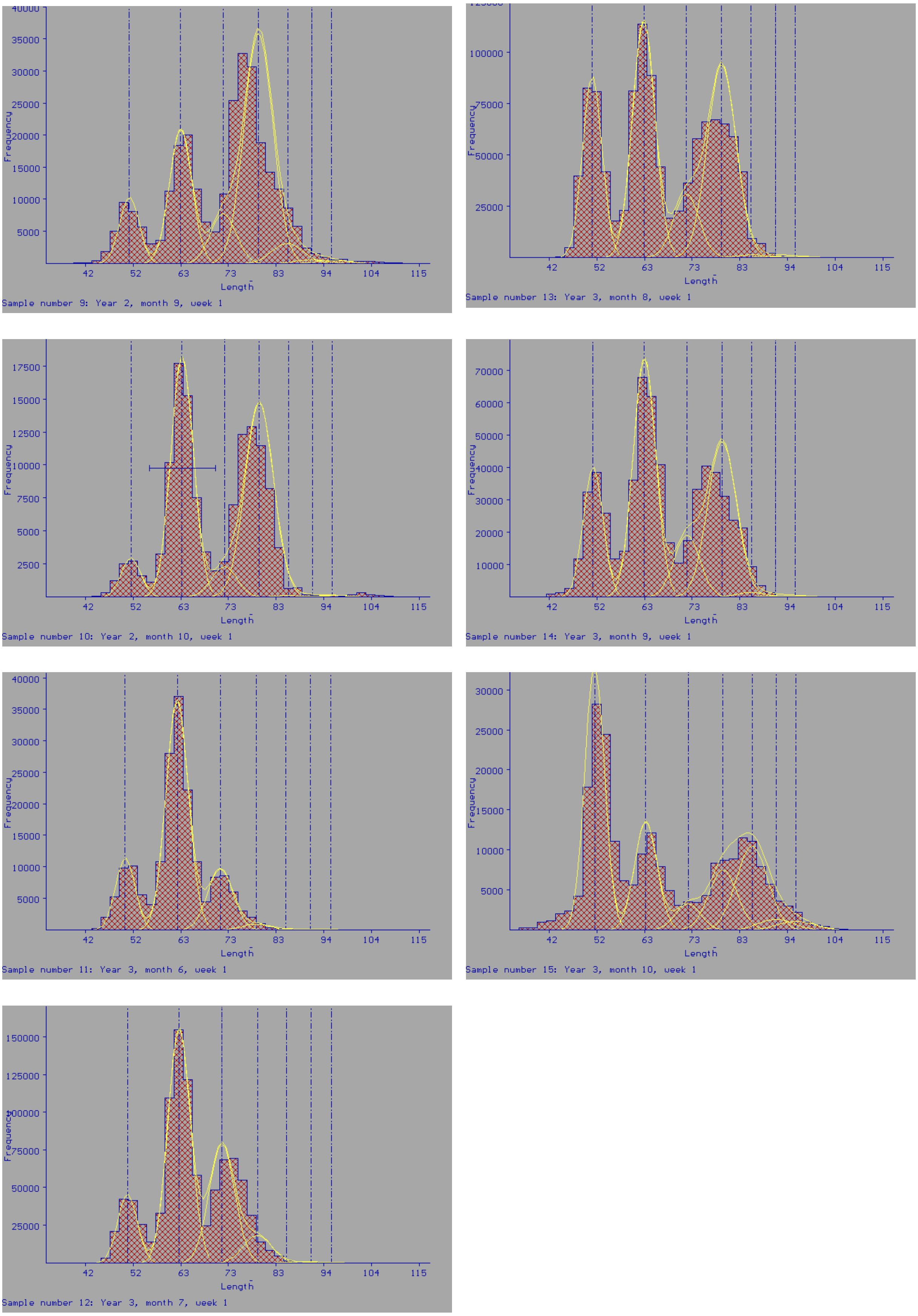

Figure 1. (continued).

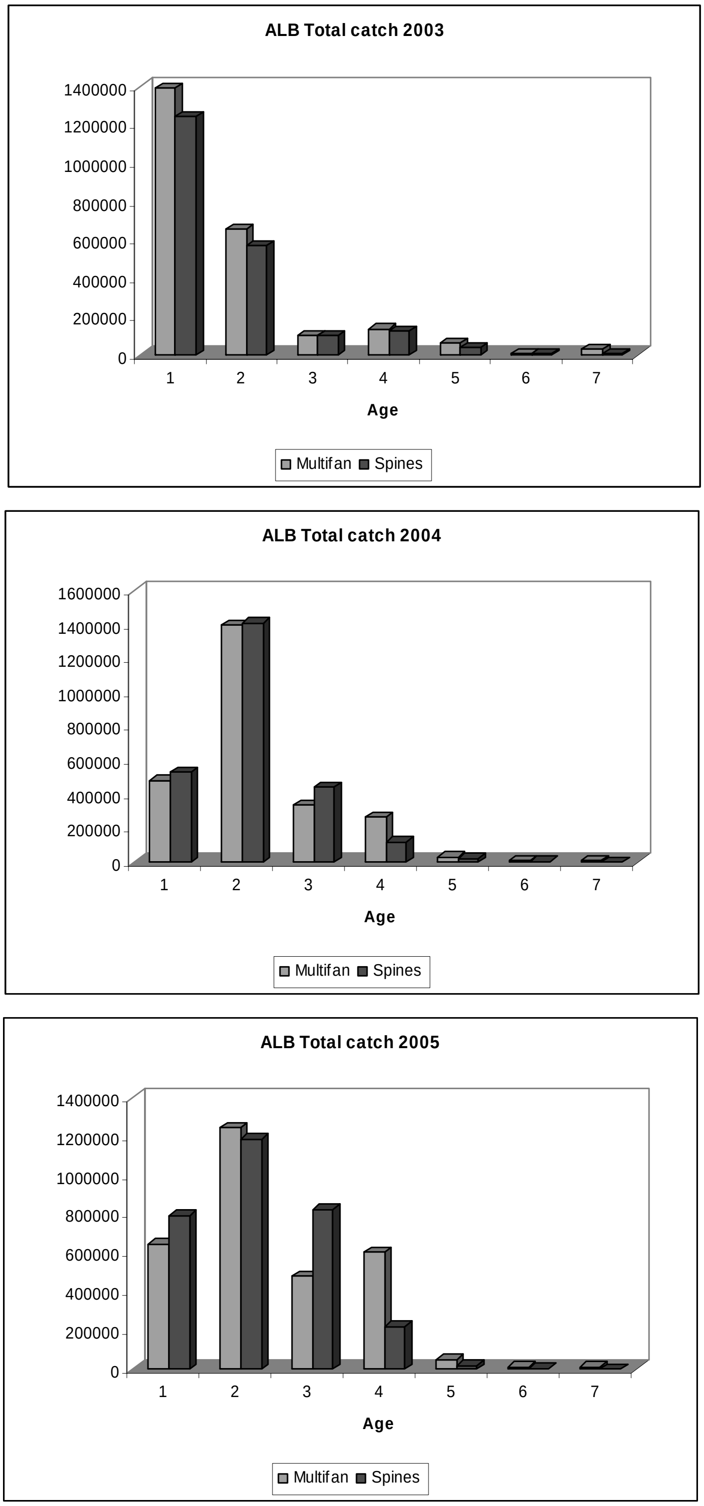

Figure 2. Age frequency distributions for the Spanish albacore surface fishery catch calculated by length frequency MULTIFAN analysis and ALK from spine readings for 2003, 2004 and 2005.

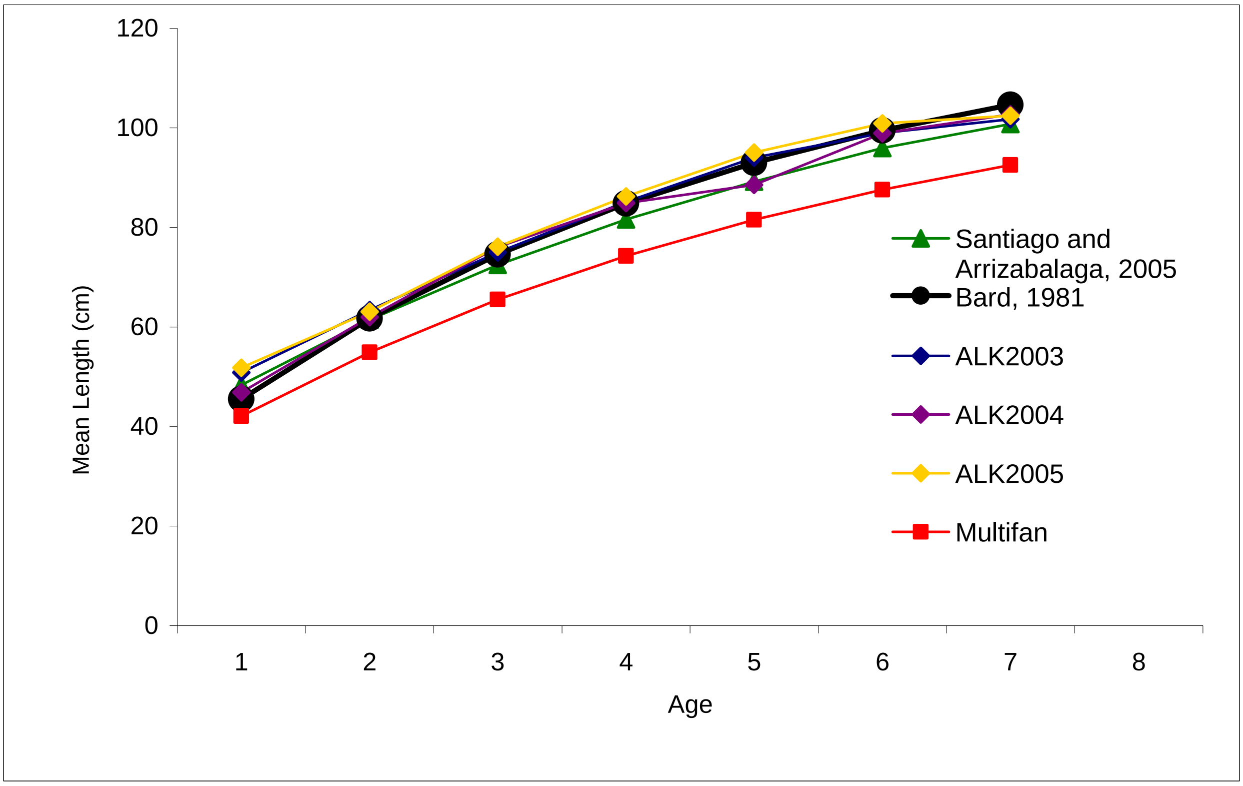

Figure 3. Mean fork length by age from MULTIFAN (2003-2005) length frequency analysis, ALKs from spine ageing (2003-2005), Bard (1981) growth equation and Santiago and Arrizabalaga (2005) growth equation for North Atlantic albacore.